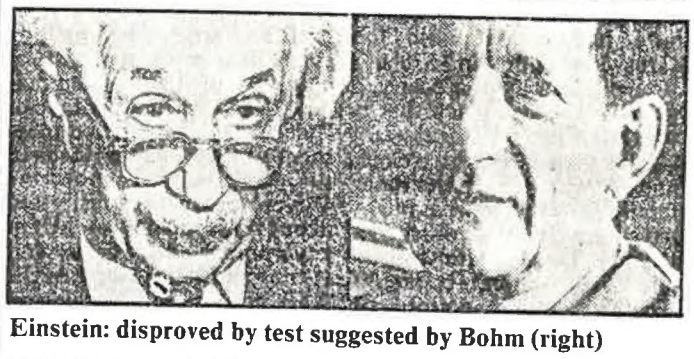

Einstein: disproved by test suggested by Bohm (right)

Why Einstein was wrong about light

EVER SINCE the comfortable certitudes of classical physics were shattered – in contradictory ways – by Einstein's Theory of Relativity and the Quantum Theory, physicists have disagreed about the nature of fundamental reality. Now the dramatic results of a crucial experiment designed to test the validity of Quantum Theory have vindicated that theory and suggested that Relativity Theory is inadequate in at least one major respect.

The issue at stake is the possible existence of instantaneous "action-at-a-distance": that is, the supposed tendency of two very distant sub-atomic particles to behave harmoniously, as though each "knew" what the other was doing. Thus if the behaviour of one such particle was altered, the other could be expected instantaneously to change in exactly the same way – with no apparent force or signal linking them.

Quantum Theory has always predicted such behaviour under certain conditions, and parapsychologists looking for a scientific explanation for such alleged phenomena as telepathy and precognition have been quick to assume it must exist. But Einstein rejected "action-at-a-distance" as "ghostly and absurd" and argued that it led to a paradox: no harmony was possible, he said, without some signal passing between the two distant particles; and yet any such signal would have to travel faster than the speed of light, and, according to Relativity Theory, that was impossible. This paradox was one reason for Einstein's life-long conviction that Quantum Theory was wrong-headed and incomplete.

In the past decade, several experiments successfully demonstrated the kind of distant harmony predicted by Quantum Theory, but they were not precise enough to settle the crucial question of instantaneity, and advocates of Relativity Theory still maintained that noting ever would. But a French team, led by Alain Aspect at the Institut d'Optique Théorique et Appliquée near Paris, recently added a crucial refinement to previous experiments which now establishes beyond doubt that, as far as action-at-a-distance is concerned, Quantum Theory was right and Einstein was wrong.

The original experiments consisted of measuring the polarisation of matched pairs of photons (bunches of light waves) emitted by a common source to see whether the behaviour of one member of the pair was affected by a measurement of the other. The result, as predicted by Quantum Theory, demonstrated that whenever photon A was measured, photon B behaved as though it too had been disturbed. Aspect's experiment improved on this by introducing a switch into the system which effectively blocked any signal passing from one photon to the other – *unless that signal was travelling faster than the speed of light.*

Clearly, Aspect's result raises problems for Relativity Theory, particularly if it should turn out that the two distant photons are linked by some sort of signal travelling faster than light. But ironically, the experiment also highlights the inadequacy of the Quantum Theory's own attempts to explain reality.

David Bohm, professor of theoretical physics at London's Birkbeck College, who devised the experiment which led eventually to Aspect's clinching result, says the real problem is that physics as we know it simply cannot make any statement about what instantaneous action-at-a-distance *means.*

"All we can do," says Bohm, "is look at several possible interpretations of the Aspect experiment. It may mean that everything in the universe is in a kind of total rapport, so that whatever happens is related to everything else; or it may mean that there is some kind of information that can travel faster than the speed of light; or it may mean that our concepts of space and time have to be modified in some way that we don't now understand. Yet whichever interpretation you choose, the experiment establishes once and for all that physics as we know it is unfinished.

"But the question," he says, "is whether physicists will regard explanations as important at all. The trend in physics at the moment is to discount concepts and only to take seriously what you can compute with equations. But in my view, the concepts are important – both for understanding what physics means and as a guide to a new physics. Aspect's result opens the way for extending quantum mechanics in a completely new direction." In the meantime, reality itself is more elusive than ever

Danah Zohar

Sunday Times
March 1983